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A PRELIMINARY REPORT ON TESTS OF THE ACCURACY OF MILK SCALES

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INTRODUCTION

Measuring the milk production of individual cows by weighing the milk at the completion of milking has been practiced for many years. Production records are desirable for individual herd management and for herd improvement association records. Changes in milk-handling equipment are making present sampling and weighing techniques increasingly inconvenient, so that new and more adaptable procedures are needed, particularly for pipe-line milking systems, to sustain a high level of participation in the testing program. Recently, during discussions of milk-flow meters, the question of accuracy has been raised. It was evident that standards must be set up to provide a basis for approving meters or other weighing devices for subsequent use in production record programs. It was generally agreed that such standards be equal to, or preferably better than, existing standards. It then became necessary to determine, as accurately as possible, what is the prevailing standard of accuracy of milk scales.

The DHIA Supervisor's Manual (AH 96 USDA) states that a 60-pound scale, graduated in tenths, is part of the standard testing equipment. The procedure states that such scales will be read to the nearest "tenth" of a pound. The section concerned with "Care of Testing Equipment" states the tester should "Check the accuracy of the scales frequently, especially if they are old."

The manual does not define the frequency of checking the accuracy of the scales, nor does it define the accuracy of the scales. Practically speaking, the matter of scale accuracy is left to the discretion of each tester. It becomes obvious that any determination of the present standards of accuracy would have to be based on checks of scales in use throughout the major milk-sheds.

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The object of these tests is to determine the present standards of accuracy of scales used for weighing milk.

It should be clearly understood that these test results were obtained from a small number of scales, which may or may not be indicative of the prevailing situation. A true evaluation of accuracy standards throughout the nation would be a formidable task.

READABILITY OF SCALE

The spring scales commonly used in weighing milk are graduated in 0.10-pound increments and have a 4-inch or 6-inch diameter dial. The readability of these scales is limited to 1/2 of one graduation, or 0.05 pound.

The effect of the readability of the scale (0.05 pound) on the total weight is expressed as a percentage in the lowest curve of Figure 1. The error due to readability becomes a part of the actual scale error when scales are checked with standard weights. Thus, any total error would have to be greater than the readability error to be of a substantial nature. For example, an error must be larger than 0.5% or 0.05 pound at the 10-pound level to be of a substantial nature.

The remainder of the curves in Figure 1 show the percentage errors of various actual errors of the common levels of milk-scale weights. For example, a scale error of 0.20 pound would provide a 1% error at 20 pounds, but only a 0.66% error at 30 pounds and only a 0.5% error at 40 pounds.

TEST IN MINNESOTA

Twenty DHIA milk scales in use in the Minneapolis-St. Paul milk-shed were checked with standard weights obtained from the Weights and Measures Department of the Minnesota Railroad and Warehouse Commission. The readings were made, after oscillating the spring, to the nearest 0.05 pound.

The weight data were obtained in 5-pound increments from 5 to 50 pounds, but were summarized at the 15-, 25-, 35-, and 45-pound readings. See Table 1.

At the 15-pound level only two scales were more than 1% in error (0.2 pound or 1.33%). Five scales were 0.1 pound or 0.67% in error.

At the 25-pound level only two scales were 1% in error (0.25 pound).

At the 35-pound level only one scale was 1% in error (0.35 pound).

At the 45-pound level none of the scales was 1% in error, and only four scales were 0.66% in error (0.30 pound).

The remainder of the readings had errors which were less than those mentioned above.

Of the 80 readings, 22 provided a zero error, 3 provided a negative error, and 55 provided a small positive error.

At the 15-pound level, the average error was 0.35%; at the 25-pound level, 0.33% error; at the 35-pound level, 0.314% error; and at the 45-pound level, 0.27% error. The overall average error was 0.32%; or the overall scale accuracy was 99.68%.

TESTS AT BELTSVILLE, MARYLAND

A typical spring scale, one commonly used for weighing milk, was checked in the Dairy Cattle Research Branch barn during a 10-day test involving 10 cows milked twice each day. Two hundred comparative weighings were made on the spring scale and on a precision bench scale. The precision bench scale was checked by the Prince George's County Department of Weights and Measures and found to be accurate to ±0.02 pound.

The milk weights varied from 4.85 pounds to 41.0 pounds, averaging 17.6 pounds. The spring scale and the bench scale agreed during 105 of the 200 readings. They differed by ±.05 pound during 81 readings, by ±.10 pound or more during 14 readings. (Table 2). Considering that the differences of ±0.05 pound could be entirely due to the readability of the scales, only 14 readings yielded a substantial difference. These 14 readings were all less than 1% in error, averaging 0.58%. In other words, 186 or 93% of the readings were within ±0.05 pound and 194 or 97% of the readings were within ±0.10 pound. The overall average error of the 200 readings was less than 1/25 of 1%.

CHECK OF TESTER'S SCALE

During the course of the scale checks, the tester visited the Dairy Cattle Research Branch barns to obtain milk weights and samples for three of the cows in the test string. A discrepancy between his spring scale weights and the one mentioned previously led to a complete check of both scales. Standard weights were used and the data obtained are presented in Table 3. The tester's scale was old and well used, and had not been checked recently. The tester's scale was found to read between 1.8% and 2.0% in excess of standard weights, with a maximum error of 0.85 pound at 45 pounds. This error is almost linear through the range and probably due to spring fatigue, a common fault of old scales.

The spring scale which was being used in the previously described tests was found to be accurate up to 30 pounds. At 35 pounds it was 0.05 pound or 0.14% low and at 45 pounds, was 0.10 pound or 0.22% low.

CHECK OF NEW SPRING SCALES

Shortly after the barn tests were concluded, a shipment of 12 new spring scales arrived at Beltsville for use in the barn. These scales were checked in the Agricultural Engineering Research Division lab with standard test

weights. The results of this check are found in Table 4. These scales were read to the nearest 0.01 pound by two men. Actually the scales are readable to the nearest 0.05 pound, but for these checks, the second decimal was estimated. One scale, #8, was found to be defective. The spring seemed to "hang" or "stick" through various weight ranges.

The check showed that all errors were less than 1%; the greatest percentage error being 0.60%, (or 0.09 pound), at 15 pounds on scale #12. The overall average error was 0.15%. Only three scales had an error greater than 0.10 pound (scales #7, 10, and 12 at 45 pounds and scale #12 at 35 pounds). Of the 44 readings, 7 provided a zero error, 7 provided a negative error, and 30 provided a positive error.

CONCLUSION

The average error of the DHIA milk scales which were checked varied from 0 to 1.89% with an overall average of 0.40% error. Individual scale readings varied from 0 to 2% in error.

The average error of 11 new milk scales varied from 0.04 to 0.35%, with an overall average of 0.15% error. Individual scale readings varied from 0 to 0.60% in error.

The weights obtained by milk scales for DHIA records, as checked in these tests, were found to have an average error of less than 1/2 of 1%. New scales were found to have an error of less than 1/6 of 1%. The greatest error found in any weight reading was only 2%, and that was found on an old scale which should not have been in service.

TABLE 1

DIFFERENCES BETWEEN MILK SCALES AND STANDARD TEST WEIGHTS(*)
(Weight Data - Minnesota - June 1957)

Standard Test Weight / Scale No.	15 Pounds* Difference #	%	25 Pounds* Difference #	%	35 Pounds* Difference #	%	45 Pounds* Difference #	%	Total %	Average %
1	0.00	0.00	0.10	0.40	0.10	0.29	0.20	0.44	1.13	0.38
2	0.10	0.67	0.15	0.60	0.20	0.57	0.30	0.66	2.50	0.63
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.10	0.29	0.05	0.11	0.40	0.10
5	0.05	0.33	0.00	0.00	0.00	0.00	-0.10	-0.22	0.55	0.14
6	0.20	1.33	0.10	0.40	0.25	0.71	0.30	0.66	3.10	0.78
7	0.00	0.00	0.00	0.00	0.15	0.43	0.15	0.33	0.76	0.19
8	0.10	0.67	0.05	0.20	0.10	0.29	0.05	0.11	1.27	0.32
9	0.00	0.00	0.05	0.20	0.00	0.00	0.05	0.11	0.31	0.08
10	0.00	0.00	0.05	0.20	0.10	0.29	0.10	0.22	0.71	0.18
11	0.00	0.00	0.05	0.20	-0.05	-0.14	0.00	0.00	0.34	0.09
12	0.05	0.33	0.10	0.40	0.00	0.00	0.05	0.11	0.84	0.21
13	0.00	0.00	0.10	0.40	0.05	0.14	0.05	0.11	0.65	0.16
14	0.10	0.67	0.05	0.20	0.10	0.29	0.10	0.22	1.38	0.37
15	0.00	0.00	0.05	0.20	0.05	0.14	0.05	0.11	0.45	0.11
16	0.20	1.33	0.25	1.00	0.35	1.00	0.25	0.55	3.88	0.97
17	0.05	0.33	0.00	0.00	0.05	0.14	0.05	0.11	0.58	0.15
18	0.10	0.67	0.20	0.80	0.25	0.71	0.30	0.66	2.84	0.71
19	0.10	0.67	0.25	1.00	0.25	0.71	0.30	0.66	3.04	0.76
20	0.00	0.00	0.10	0.40	-0.05	-0.14	0.00	0.00	0.54	0.14
Totals		7.00		6.60		6.28		5.39	25.27	
Average		0.35		0.33		0.31		0.27	1.26	0.32

All values are positive except where the negative sign is found.

TABLE 2

DISTRIBUTION OF DIFFERENCES BETWEEN A MILK SCALE AND A PRECISION BENCH SCALE
(Weight Data - Beltsville - May 1957)

Amount of Difference	-0.20#		-0.15#		-0.10#		-0.05#	0.00#	+0.05#	+0.10#		+0.15#
Frequency of Difference	1		9		8		65	105	16	1		0
	Weight #	Error %	Weight #	Error %	Weight #	Error %	-	-	-	Weight #	Error %	-
	41.0	0.49	30.25	0.50	11.15	0.90				25.1	0.40	
			31.45	0.48	12.05	0.83						
			34.50	0.43	12.70	0.79						
			34.85	0.43	13.05	0.77						
			Average	0.46	13.10	0.76						
					13.45	0.74						
					31.50	0.32						
					36.95	0.27						
					Average	0.67						

TABLE 3

DIFFERENCES BETWEEN TWO MILK SCALES AND STANDARD TEST WEIGHTS
(Weight Data - Beltsville - May 1957)

Standard Test Weight	15 Pounds		25 Pounds		35 Pounds		45 Pounds		Total	Average
	Difference		Difference		Difference		Difference			
	#	%	#	%	#	%	#	%	%	%
Tester's Scale	0.30	2.00	0.45	1.80	0.65	1.86	0.85	1.89	7.55	1.89
Test Scale	0.00	0.00	0.00	0.00	-0.05	-0.14	-0.10	-0.22	-0.36	-0.09

All values are positive except where the negative sign is found.

TABLE 4

DIFFERENCES BETWEEN 12 NEW SPRING SCALES AND STANDARD TEST WEIGHTS(*)
(Weight Data - Beltsville - 1957)

Standard Test Weight	15 Pounds*		25 Pounds*		35 Pounds*		45 Pounds*			
Scale No.	Difference		Difference		Difference		Difference		Total	Average
	#	%	#	%	#	%	#	%	%	%
1	-0.01	-0.07	0.02	0.08	0.04	0.11	0.02	0.04	0.30	0.08
2	-0.02	-0.13	0.02	0.08	0.08	0.23	0.10	0.22	0.67	0.14
3	0.01	0.07	0.05	0.20	0.05	0.14	0.02	0.04	0.45	0.11
4	0.01	0.07	0.01	0.04	0.07	0.20	0.03	0.07	0.38	0.10
5	0.01	0.07	-0.05	-0.20	0.00	0.00	0.00	0.00	0.27	0.07
6	-0.01	-0.07	0.00	0.00	0.00	0.00	0.05	0.11	0.18	0.05
7	0.05	0.33	0.08	0.32	0.10	0.28	0.11	0.24	1.17	0.29
8	Defective Scale									
9	-0.04	-0.27	-0.05	-0.20	-0.05	-0.14	0.03	0.07	0.68	0.17
10	0.02	0.13	0.05	0.20	0.10	0.28	0.13	0.29	0.90	0.23
11	0.00	0.00	0.00	0.00	0.05	0.14	0.00	0.00	0.14	0.04
12	0.09	0.60	0.10	0.04	0.18	0.51	0.11	0.24	1.39	0.35
Totals		1.81		1.36		2.03		1.32	6.53	1.63
Average		0.16		0.12		0.18		0.12	0.59	0.15

All values are positive except where the negative sign is found.

ACTUAL SCALE ERROR EXPRESSED AS A PERCENTAGE OF THE TOTAL WEIGHT